



# Empirical Formula & Molecular Formula

## Answers

1. For the following experimental percent composition, find the empirical formula of the compound:

$$\begin{array}{l}
 \text{Moles of C} = 54.5 \text{ g} / 12.01 \text{ g/mol} = 4.5 \text{ moles} / 2.28 \text{ moles} = 2 \\
 \text{Moles of H} = 9.1 \text{ g} / 1.01 \text{ g/mol} = 9.01 \text{ moles} / 2.28 \text{ moles} = 4 \\
 \text{Moles of O} = 36.4 \text{ g} / 16.00 \text{ g/mol} = 2.28 \text{ moles} / 2.28 \text{ moles} = 1
 \end{array}
 \quad \left| \quad \text{Empirical formula} = \text{C}_2\text{H}_4\text{O}$$

$$\begin{array}{l}
 \text{Empirical formula mass} = (2 \times 12.01) + (4 \times 1.01) + (1 \times 16.00) = 44 \text{ g/mol} \\
 \text{Ratio} = \text{Molar mass} / \text{Empirical formula mass} = 88 \text{ g} / 44 \text{ g/mol} = 2 \\
 \text{Molecular formula} = (\text{C}_2\text{H}_4\text{O})_2 = \text{C}_4\text{H}_8\text{O}_2
 \end{array}$$

2. Find the molecular formula of a compound that contains 4.90 g N and 8.40 g O. The molar mass of the compound is 152.0 g/mol.

$$\begin{array}{l}
 \text{Mass of the compound} = 4.90 \text{ g} + 8.40 \text{ g} = 13.3 \text{ g} \\
 \text{Percent composition of N} = 4.90 \text{ g} / 13.3 \text{ g} \times 100 = 36.8\% \\
 \text{Percent composition of O} = 8.40 \text{ g} / 13.3 \text{ g} \times 100 = 63.2\% \\
 \text{Moles of N} = 36.8 \text{ g} / 14.01 \text{ g/mol} = 2.63 \text{ moles} / 2.63 \text{ moles} = 1 \times 2 = 2 \\
 \text{Moles of O} = 63.2 \text{ g} / 16.00 \text{ g/mol} = 3.95 \text{ moles} / 2.63 \text{ moles} = 1.5 \times 2 = 3
 \end{array}
 \quad \left| \quad \text{Empirical formula} = \text{N}_2\text{O}_3$$

$$\begin{array}{l}
 \text{Empirical formula mass} = 2 \times 14.01 \text{ g/mol} + 3 \times 16.00 \text{ g/mol} = 76 \text{ g/mol} \\
 \text{Ratio} = 152 \text{ g/mol} / 76 \text{ g/mol} = 2 \qquad \qquad \qquad \text{Molecular formula} = (\text{N}_2\text{O}_3)_2 = \text{N}_4\text{O}_6
 \end{array}$$

3. The empirical formula of a compound is CH<sub>2</sub>. Its molecular mass is 70 g/mol. What is its molecular formula?

$$\begin{array}{l}
 \text{Empirical formula mass} = 12.01 \text{ g/mol} \times 1 + 1.01 \text{ g/mol} \times 2 = 14.03 \text{ g/mol} \\
 \text{Ratio} = 70 \text{ g/mol} / 14.03 \text{ g/mol} = 5 \\
 \text{Molecular formula} = (\text{CH}_2)_5 = \text{C}_5\text{H}_{10}
 \end{array}$$

4. What is the molecular formula of the molecule with an empirical formula of CH<sub>2</sub>Cl and a molar mass of 247.5 g/mol?

$$\begin{array}{l}
 \text{Empirical formula mass} = (1 \times 12.01 \text{ g/mol}) + (2 \times 1.01 \text{ g/mol}) + (1 \times 35.5 \text{ g/mol}) = 49.48 \text{ g/mol} \\
 \text{Ratio} = 247.5 \text{ g/mol} / 49.48 \text{ g/mol} = 5 \\
 \text{Molecular formula} = (\text{CH}_2\text{Cl})_5 = \text{C}_5\text{H}_{10}\text{Cl}_5
 \end{array}$$